SOLID AND SEMI-FLEXIBLE BODY INKJET PRINTING SYSTEM

Field of the Invention

This invention relates generally to printing with an inkjet printing mechanism, and more particularly to a new handheld, solid and semi-flexible body inkjet printing system for printing images on hard or semi-flexible surfaces, and in particular, on human skin, such as for face-painting at carnivals, for temporary tattoos, for body decorations, and the like.

Background of the Invention

Typical inkjet printing mechanisms use cartridges, often called "pens," which shoot drops of liquid colorant, referred to generally herein as "ink," onto a page. Each cartridge has a printhead formed with very small nozzles through which the ink drops are fired. Most often, the printhead is held in a carriage that slides back and forth along a guide rod in a "reciprocating printhead" system, with the page being advanced in steps between each pass of the printhead. To print an image on paper media, for instance, the printhead is propelled back and forth across the page, shooting drops of ink in a desired pattern as it moves. Other printing systems, known as "page-wide array" printers, extend the printhead across the entire page in a stationary location and print as the media advances under the printhead. The particular ink ejection mechanism within either type of printhead may take on a variety of different forms known to those skilled in the art, such as those using piezo-electric or thermal printhead technology.

For instance, two earlier thermal ink ejection mechanisms are shown in U.S. Patent Nos. 5,278,584 and 4,683,481, both assigned to the present assignee, Hewlett-Packard Company. In a thermal system, a barrier layer containing ink channels and vaporization chambers is located between a nozzle orifice plate and a substrate layer. This substrate layer typically contains linear arrays of heater elements, such as resistors, which are energized to heat ink within the vaporization chambers. Upon heating, an ink droplet is ejected from a nozzle associated with the

energized resistor. By selectively energizing the resistors as the printhead moves across the page, the ink is expelled in a pattern on the print media to form a desired image (e.g., picture, chart or text).

To clean and protect the printhead, typically a "service station" mechanism is mounted within the printer chassis so the printhead can be maintained to promote printhead health. For storage, or during non-printing periods, the service stations usually include a capping system which hermetically seals the printhead nozzles from contaminants and drying. Some caps are also designed to facilitate priming, such as by being connected to a pumping unit that draws a vacuum on the printhead. During operation, clogs in the printhead are periodically cleared by tiring a number of drops of ink through each of the nozzles in a process known as "spitting," with the waste ink being collected in a "spittoon" reservoir portion of the service station. After spitting, uncapping, or occasionally during printing, most service stations have an elastomeric wiper that wipes the printhead surface to remove ink residue, as well as any paper dust or other debris that has collected on the printhead. The wiping action is usually achieved through relative motion of the printhead and wiper, for instance by moving the printhead across the wiper, by moving the wiper across the printhead, or by moving both the printhead and the wiper.

To improve the clarity and contrast of the printed image, recent research has focused on improving the ink itself. To provide quicker, more waterfast printing with darker blacks and more vivid colors, pigment-based inks have been developed. These pigment-based inks have a higher solid content than the earlier dye-based inks, which results in a higher optical density for the new inks. Both types of ink dry quickly, which allows inkjet printing mechanisms to form high quality images on readily available and economical plain paper. Typically, these inks are supplied in a reservoir housed by the inkjet cartridge, so when the reservoir is emptied, the entire cartridge including the printhead is replaced in what is known as a "replaceable cartridge" system. Some cartridges are monochrome (single color), for instance, carrying only black ink, while other cartridges are multi-color, typically carrying cyan, magenta and yellow inks. Some printing mechanisms use four

monochrome cartridges, while others use a black monochrome cartridge in combination with a tri-color cartridge.

Recently, an imaging cartridge system has been introduced by the Hewlett-Packard Company of Palo Alto, California, as the DeskJet@ 693C model inkjet printer. This is a two-pen printer which uses a tri-color cartridge, carrying full dye-loads of cyan, magenta and yellow, and a black cartridge which may be replaced with a tri-color imaging cartridge. This imaging cartridge carries reduced dye-load concentrations of some colors, such as cyan and magenta, along with a full or partial dye-load concentration of black ink. The imaging cartridge allows the printer to produce more continuous tone changes, particularly flesh tones, so the resulting image has near-photographic quality, with very little graininess.

As the inkjet industry investigates new printhead designs, one tendency is toward using a "snapper" reservoir system where permanent or semi-permanent printheads are used and a reservoir carrying a fresh ink supply is snapped into place on the printhead. These snapper reservoirs are typically installed in reciprocating printers, which move both the printhead and the snapper reservoir back and forth across the media for printing. Another new design uses permanent or semi-permanent printheads in what is known in the industry as an "off-axis" printer. In an off-axis system, the printheads carry only a small ink supply reciprocally back and forth across the printzone, with this on-board supply being replenished through tubing that delivers ink from an "off-axis" main reservoir placed at a remote, stationary location within the printer. Rather than purchasing an entire new cartridge which includes a costly new printhead, the consumer buys only a new supply of ink or an "ink bag" for the main reservoir. Typically, the fresh ink supplies are sold individually by color, although in some implementations, a multi-color supply may be furnished.

From the discussion above, it is apparent that the vast majority of inkjet printing has been done on paper, although inkjet printing is often done on transparencies, foils, fabrics and other sheet-like media. It would be desirable to provide a new system which expands the concepts of inkjet printing to other uses, such as for printing images on hard or semi-flexible surfaces, and in particular, on

human skin, such as for face-painting at carnivals and the like, in a manner that is both easy and economical to use. The matter of permanence, semi-permanence or temporariness of the printed image may be governed, at least in part, by the selection of the ink used to print the image, as well as the environment to which the printed image is exposed.

Summary of the Invention

According to one aspect of the invention, a inkjet printing system is provided to print an image using inkjet technology on a print media which may be non-sheet-like, such as upon a hard surface, for instance, lumber which is ready to be shipped on a pallet to a jobsite, or on a semi-flexible surface like human skin when face-painting at carnivals, for temporary tattoos, for body decorations, and the like. The printing system includes a handheld inkjet printing mechanism for printing a selected image on a print surface of a solid body or a semi-flexible body. This handheld printing mechanism has a chassis, and a controller supported by the chassis, with the controller storing the selected image. An inkjet printhead is supported by the chassis to selectively eject inkjet ink onto the print surface in response to the controller. A printhead-to-print surface spacing device controls the spacing between the printhead and the print surface. The spacing device is supported by the chassis to traverses over the print surface when moved along the print surface by an operator while the printhead selectively ejects ink onto the print surface to record the selected image thereon.

According to yet another aspect of the invention, a method is provided of printing a selected image on a print surface of a solid body or a semi-flexible body, including the step of traversing a chassis supporting an inkjet printhead over the print surface. During the traversing step, in a maintaining step, a selected spacing is maintained between the inkjet printhead and the print surface. In an ejecting step, ink is selectively ejected from the printhead to record the selected image on the print surface during the traversing step.

An overall goal of the present invention is to provide an inkjet printing system and method for printing on non-sheet-like material, such as hard or

semi-flexible surfaces, such as skin for pace-painting and the like, which is fast, economical, and easy to use, along with providing superior print quality.

A further goal of the present invention is to provide an economical inkjet cartridge or replaceable ink supply for use with such a printing system, which is economical and easy for consumers to install, and which prints on and adheres to skin.

Another goal of the present invention is to provide a portable, handheld, inkjet printing system which may download images from a computer or scanner, or which may accept image cartridges having one or more images stored thereon, and which may have a display screen to preview the image to be printed, as well as a device which may allow for customization of the image in the field, such as the addition of a name or other information.

Brief Description of the Drawings

FIG. 1 is a partially schematic, perspective view of one form of a portable, solid body and semi-flexible body inkjet printing mechanism of the present invention, shown here printing an image on a semi-flexible skin surface of an arm.

FIG. 2 is a side elevational view of the inkjet printing mechanism of FIG. 1.

FIG. 3 is a bottom plan view of the inkjet printing mechanism of FIG. 1.

FIG. 4 is a partially schematic, perspective view of an alternate form of a portable, solid body and semi-flexible body inkjet printing mechanism of the present invention, shown here coupled to two different image input devices, one being a scanner for loading custom images, and the other being a computer, along with a replaceable inkjet ink supply ready to be installed in the printing mechanism.

FIG. 5 is an enlarged side elevational view of the inkjet printing mechanism of FIG. 4, shown ready for installation into storage and printhead servicing mechanism used to maintain printhead health.

Detailed Description of the Preferred Embodiments

FIGS. 1-3 illustrate one embodiment of a portable, solid body and semi-flexible body inkjet printing mechanism 20, constructed in accordance with the present invention, which may be used for printing of information, photographic images, designs, graphics, and the like, such as the moon and stars design 22 on a solid body or a semi-flexible body, such as the skin 24 covering arm 25, in an industrial, office, home or other environment. This body inkjet printing system may be used in a variety of different portable, hand-held configurations to print images on other surfaces, such as for marking packages in a warehouse, field-marking containers, or pallets of lumber. Many other industrial, business, study and home uses for this portable printer 20 may be envisioned, where a light-weight, portable, easily-read marking system is desired. For convenience the concepts of the present invention are illustrated in the environment of a portable inkjet printer 20 used to form images on the semi-flexible surface of human skin 24. The print media may be any type of hard or semi-flexible material, but for convenience, the illustrated embodiment is described using skin 24.

While it is apparent that the printer components may vary from model to model, the illustrated inkjet printer 20 includes a first chassis portion comprising a frame or base 26 surrounded by a second chassis portion comprising a housing, casing or enclosure 28, typically of a plastic material. A group of four rollers or wheels 30, 32, 34 and 36 are rotationally mounted to the chassis base 26 to move the printer 20 evenly over the print surface, here, skin 24, in the direction of arrow 38. The printer 20 also has a printer controller, illustrated schematically as a microprocessor 40, which in this embodiment receives print instructions from a replaceable, interchangeable image cartridge 42. The image cartridge 42 is illustrated as being slideably received in a slot 44 defined by the chassis housing 28 to be electrically coupled to the controller 40 when fully inserted in the slot 44. The cartridge 42 may include a display surface 45 that carries indicia indicating the image or images which may be printed when the cartridge is installed in printer 20. Preferably, the chassis housing 28 defines a window 46 through which indicia printed on the display surface 45 may be viewed when the cartridge 42 is installed.

It is apparent that use of a replaceable image cartridge 42 has many advantages, depending upon the configuration selected for the controller 40. For example, the main portion of the microprocessor may be housed within the image cartridge 42, allowing consumers to upgrade the printing abilities of their printer when a new cartridge 42 is purchased. As an alternative to such a "smart cartridge" embodiment, the controller 40 may be constructed to house the main portion of the microprocessor, leaving the cartridge 42 to only carry data to the controller to provide a more expensive printer 20, and more economically priced image cartridges 42. Thus, as used herein, the term "printer controller 40" encompasses these functions, whether performed by the on-board portion of the controller 40, by the cartridge 42, an intermediary device therebetween or linked thereto, or by a combined interaction of such elements. The printer controller 40 may also operate in response to user inputs provided through a key pad 48 or other input device located on the exterior of the chassis casing 28.

In the illustrated example, the skin 24 receives ink from a pair of inkjet cartridges 50 and 52, which may be monochrome cartridges, such as a black ink cartridge and/or a color ink cartridge. The cartridges 50 and 52 are also often called "pens" by those in the art. The pens 50, 52 are received within a receptacle 53 formed within the chassis housing 28 and aligned to the chassis base 26 using conventional datums, for instance as described in U.S. Patent Nos. 4,872,026 and 5,617,128, both assigned to the Hewlett-Packard Company of Palo Alto, California. Multi-color images may be printed using tri-color cartridges, with a black image being formed by printing dots of cyan, magenta and yellow all at the same location, forming what is known in the art as a "process black," as opposed to a "true black" which would be formed by printing with a black ink cartridge. The pens 50, 52 may contain pigment based inks, dye based inks, or other types of inks, such as thermoplastic, wax or paraffin based inks, as well as hybrid or composite inks having both dye and pigment characteristics.

The illustrated pens 50, 52 each include reservoirs for storing a supply of ink. The pens 50, 52 have printheads 54, 55 respectively, each of which have an orifice plate with a plurality of nozzles (not shown) formed therethrough in a manner well

known to those skilled in the art. The illustrated printheads 54, 55 are thermal inkjet printheads, although other types of printheads may be used, such as piezoelectric printheads. The printheads 54, 55 typically include a substrate layer having a plurality of resistors which are associated with the nozzles. Upon energizing a selected resistor, a bubble of gas is formed to eject a droplet of ink from the nozzle and onto the print surface, such as skin 24. The printhead resistors are selectively energized in response to enabling or firing command control signals, which may be delivered by a conventional multi-conductor strip (not shown) from the controller 40 to the printheads, and through conventional electro-mechanical interconnects between the cartridge receptacle 53 defined by the chassis housing 28 and the pens 50, 52, then to the printheads 54, 55.

Preferably, the outer surface of the orifice plates of the printheads 54, 55 lie in a common printhead plane. This printhead plane may be used as a reference plane for establishing a desired media-to-printhead spacing, which is one important component of print quality. In the illustrated embodiment, the media-to-printhead spacing is determined by the extent to which the wheels 30-36 project beyond the lower surface of the printheads 54, 55, as can best be seen in the view of FIG. 2. Of course there may be some flexibility to the surface of the skin 24, into which the wheels may protrude, requiring a larger media-to-printhead spacing distance than would be required when printing on a solid surface, such as on lumber or on drywall (also known in the building trades as "sheet rock"). This variance in the print surface characteristics may be accommodated by making the wheels 30-36 of a larger diameter for semi-flexible print surfaces like skin, such as by using interchangeable wheels, or by allowing an operator to adjust the wheel height relative to the bottom surface of the housing using a conventional lever or screw mechanism (not shown).

As shown in FIG. 1, to track the linear position of the printer 20 as it moves across the skin 24 in the direction of arrow 38, the printer 20 may include a positional feedback mechanism, such as a conventional rotary encoder 56 which may be mounted to the circular side surface of one of the wheels, for instance on wheel 30. An optical encoder reader 58 may be mounted to the chassis base 26 to

read the indicia on the rotary encoder 56 and provide a positional signal to controller 40. Such a rotary encoder system 56, 58 is known in the art for monitoring media position, such as when a sheet of media advances through the printzone, for instance as described in U.S. Patent No. 5,774,074. As an operator rolls printer 20 across the skin 24, the controller 40 coordinates the firing signals sent to the inkjet nozzles of printheads 54, 55 with the positional feedback signal received from the encoder reader 58 to direct the ink droplets to print the image 22 according to the instructions on the image cartridge 42, or according to information stored in the controller 40.

FIGS. 4 and 5 illustrate another embodiment of a portable, solid body and semi-flexible body inkjet printing mechanism 60, constructed in accordance with the present invention, which may be used for printing of information, photographic images, designs, graphics, and the like, such as the moon and stars design 22', on a solid body or a semi-flexible body, such as the skin 24 covering arm 25, in an industrial, office, home or other environment. The functions and features of printer 60 are similar to those described above for printer 20, and both embodiments may be likewise adapted to have similar features. Here we see printer 60 coupled to a host computer 62 from which images, such as design 22' may be downloaded through a signal 64, which may be hard-wired to the printer at terminal 65, or may be otherwise downloaded, such as through an infrared or other signal. The design 22' may also be provided to the printer 60 from a scanner 66 through a signal 67, which may be hard-wired to the printer at terminal 68, or may be otherwise downloaded, such as through an infrared or other signal. Alternatively, the image 22' may be provided through an image cartridge, as described above for printer 20. Images to be printed may be downloaded from other sources, such as from the Internet or world-wide web.

The printer 60 holds four replaceable ink reservoirs 70, 72, 74 and 76 which contain black, cyan, magenta and yellow inks, respectively, within receptacles defined by a first chassis portion comprising a main housing or enclosure portion 78 of the printer. The printer 60 has a second chassis portion comprising a printhead housing 80 which is flexibly mounted to the main enclosure 78 at a flexible,

gimbal-mounted, neck portion 82. The chassis main enclosure 78 may be equipped with a display portion 84, such as an LCD (liquid crystal display) screen that displays usage instructions, or a representation of an image 22' to be printed. Image selection input keys 85 may be used to scroll through a variety of images stored in a controller portion of the printer, which may operate as described above for the controller 40. Images may be customized through inputs provided by a keyboard, such as an alpha-numeric keyboard 86. Other input keys 88 may also be provided on the exterior of the chassis housing 78, such as to begin a print job, or this location may be used to provide an operator with information, such as whether to speed-up or slow down when moving across a print surface, such as skin 24 (FIG. 1).

The chassis printhead housing 80 holds four inkjet printheads 90, 92, 94 and 96 which are coupled to the reservoirs 70, 72, 74 and 76, respectively, through a series of ink delivery tubes 100, 102, 104 and 106, respectively, which extend through the neck portion 82. While the printheads 90-96 are illustrated as being four separate items, as advances in inkjet technology and silicon manufacturing techniques are made, it may be very feasible now, or in the near future to form four large printheads, for instance having nozzles arrays of an inch (2.54 centimeters) or longer, on a single piece of silicon. The ink delivery tubes 1 00- 106 may be constructed from a variety of different ink-compatible flexible tubing materials, such as the plastic tubing used in the Hewlett-Packard Company's DeskJet@ 2000C Professional Series inkjet printer. Indeed, the printheads 90-96, as well as the ink reservoirs 70-76, may be constructed using the technology employed in the DeskJet@ 2000C Professional Series inkjet printer.

To maintain a proper printhead-to-print surface spacing, the printhead housing 82 may include a group of wheels as described above for wheels 30-36, or a group of fixed spacer protrusions or skids 110, 112, 114 and 116. The skid bumps 110-l 14 slide over the print surface, such as skin 24. The chassis printhead housing 80 may also carry an optical sensor 120 which may be used to provide a positional feedback signal to the printer controller, as described above with respect to the encoder 58 of printer 20, or if equipped with wheels 30-36 rather than with the skids 110-l 16, a rotary encoder may be used, as described above for encoder 56.

Such an optical sensor 120 may be used to view surface irregularities in the print surface such as hairs on the skin, and from this information, determine the speed of the printing stroke 38. Alternatively, a strip of tape carrying regularly-spaced markings or other indicia may be placed on the print surface to lie under sensor 120 during the print stroke, with the tape acting then as a linear encoder and the sensor 120 acting as an optical pattern sensor to generate a positional feedback signal.

As described above in the Background section, inkjet printheads require servicing to maintain pen health. In conventional inkjet printers used to print on sheet media, a service station is typically mounted within the printer housing. For a portable, handheld printer 20 or 60, to keep the printer unit light weight for ease of use, a separate service station unit 130 is useful. The service station 130 may be constructed in a variety of different ways known to those skilled in the art, for instance, using the principles described in the allowed U.S. Patent Application Serial No. 08/667,610, filed on July 3, 1996, and assigned to the Hewlett-Packard Company. The illustrated service station 130 has a receptacle 132 which is sized to receive and grip the chassis printhead housing 80, as indicated by arrow 134. The service station 130 has a motor 136 which moves the various servicing components, such as wipers and caps into place to service the printheads 90-96, for instance, in response to inputs received from an operator through a keypad 138. For instance, a spitting and wiping routine may be required following a print job, followed thereafter by a capping sequence for periods of storage. One of the inputs to keypad 138 may be used to initiate a spitting and wiping routine following a period of storage to ready the printer 20, 60 for printing.

Conclusion

A variety of advantages are realized using the handheld inkjet printer 20, 60, beyond the ability to use inkjet technology to print on non-traditional solid body and semi-flexible body print surfaces, as well as on conventional sheet media, such as paper. Preferably, the printers 20, 60 are lightweight and portable, for instance about the same size as a man's electric shaver or a cellular telephone. One advantage of

the gimbal-mounted neck 82 of printer 60 is the ability to keep the chassis printhead housing 80 flush with the print surface, allowing for some natural ergonomic tilting of the operator's hand holding the chassis main body 78 while printing, without inducing drop trajectory print defects in the image 22.

The ability to couple the printer 60 to a computer 62 allows the latest in imaging and photo software to be used to generate images, including customized images, as well as images entered through scanner 66, for instance the photo of a boyfriend, girlfriend, or one's favorite pet or hobby. Indeed, the computer 62 may be used to download images from a website on the Internet. The alpha-numeric keypad 48, 86 on the printer 20, 60 may allow for further customization of images when printing at a location which is remote from a computer, such as when face-painting at a carnival where a child might wish to have their name printed on their skin instead of, or in addition to a design. The alpha-numeric keypad 48, 86 may also be useful in other contexts, such as when marking containers during an inventory at a warehouse. Such inventory information could also be stored in the controller 40 of printer 20 or 60, and later downloaded onto the computer 62. Indeed, the handheld printers 20, 60 may be used to print on other surfaces, such as for applying tole or other designs to furniture or walls, or for addressing packages to eliminate adhesive mailing labels.

While the initial thought was to apply a washable ink to the skin for temporary images, in some printing situations, a more permanent ink may be desirable, such as for marking containers in a warehouse. A semi-permanent ink may be desirable for applying an image to the skin instead of a getting a permanent tattoo, with the inkjet image eventually fading away, which may also be useful as a precursor to getting a permanent tattoo to first decide whether one really likes the image selected. Depending upon the type of ink(s) used and the nature of the particular print surface, some preparation of the print surface prior to printing may be desirable, such as wiping skin 24 with an alcohol-soaked pad before printing to assure a clean surface for good ink adhesion.

While the illustrated embodiments of printers 20 and 60 both include positional feedback to the controller 40, using the optical rotary encoder 56 and

reader 58 in FIG. 1, and the optical sensor 120 in FIG. 4, positional feedback is not a requirement if an operator has a steady hand with a smooth print stroke, such as in the direction of arrow 38 in FIG. 2. With a positional feedback system, the display screen 84 may be used to display usage instructions to indicate whether and operator should speed-up or slow down a printing stroke for optimal image quality. It is apparent that a variety of other modifications may be made in implementing the concepts of this invention, as illustrated by the embodiments of printers 20 and 60, in particular when tailoring these handheld portable printers for particular uses, and the examples discussed above are merely to illustrate a few of the different ways in which such modifications may be made.

MEASUREMENT AND MARKING DEVICE

The Field of the Invention

The present invention relates generally to measurement systems and, more particularly to a hand-held device for measuring an object, marking the object with a measurement, and/or transferring a measurement of the object to another object.

Background of the Invention

To transfer a measurement from a first object to a second object, a user typically follows a process of making and reading the measurement at the first object, recording the measurement by mentally remembering and/or physically writing down the measurement, and reproducing the measurement at the second object by marking the measurement on the second object. Conventional measurement devices for making the measurement include tape measures, scales or rulers, micrometers, etc. Conventional marking devices for recording and/or transferring the measurement include pencils, chalk lines, scribes, etc. Thus, the user must handle or operate a separate measurement device and a separate marking device for transfer of the measurement from the first object to the second object. In addition, the user may also require the use of a recording medium, such as paper, for recording of the measurement during the transfer process.

Unfortunately, any number of errors my occur in the typical measurement transfer process. For example, inaccurate making or reading of the measurement at the first object may occur, inaccurate recording of the measurement by the user may occur, and/or inaccurate reproduction of the measurement at the second object may occur. Transferring multiple measurements, therefore, increases the possibility of such errors. In addition, transferring multiple measurements requires that the process be repeated several times. Understandably, repeating the process several times is tedious. As such,

the typical method of transferring a measurement from a first object to a second object is often inefficient and time consuming. In addition, accurately forming a plurality of measurement markings at predetermined intervals on an object with conventional measurement devices and conventional marking devices is difficult.

Accordingly, a need exists for a device which facilitates measurement of an object and marking of the object with a measurement, as well as transfer of a measurement of the object to another object.

Summary of the Invention

One aspect of the present invention provides a measurement and marking device. The measurement and marking device includes a housing, a positional sensing assembly mounted in the housing, a printhead assembly mounted in the housing, and a controller mounted in the housing and communicating with the positional sensing assembly and the printhead assembly. The positional sensing assembly is adapted to sense a position of the housing relative to an object as the housing is moved along a surface of the object and the printhead assembly is adapted to print on the surface of the object as the housing is moved along the surface of the object. As such, the controller is adapted to operate the printhead assembly to print a mark on the surface of the object based on the position of the housing relative to the object as the housing is moved along the surface of the object.

Another aspect of the present invention provides a method of printing a measurement marking on an object. The method includes moving a housing along a surface of the object, sensing a position of the housing relative to the object, and printing the measurement marking on the surface of the object when the position of the housing relative to the object corresponds to a predetermined position.

Another aspect of the present invention provides a method of transferring a measurement of a first object to a second object. The method first includes moving a housing along a surface of the first object, sensing a position of the

housing relative to the first object as the housing is moved along the surface of the first object, and locating a feature of the first object by recording the position of the housing at the feature of the first object. The method then includes moving the housing along a surface of the second object, sensing a position of the housing relative to the second object as the housing is moved along the surface of the second object, and printing a mark representing the feature of the first object on the surface of the second object when the position of the housing relative to the second object coincides with the position of the housing at the feature of the first object.

Brief Description of the Drawings

Figure 1 is a block diagram illustrating one embodiment of a measurement and marking device according to the present invention;

Figure 2 is a schematic top perspective view of one embodiment of a measurement and marking device according to the present invention;

Figure 3 is a bottom perspective view of the measurement and marking device of Figure 2 illustrating one embodiment of a positional sensing assembly according to the present invention;

Figure 4 is a bottom perspective view similar to Figure 3 illustrating another embodiment of a positional sensing assembly according to the present invention;

Figure 5 is a schematic illustration of one embodiment of printing measurement markings on an object with a measurement and marking device according to the present invention;

Figures 6A, 6B, 6C, 6D, and 6E are schematic illustrations of one embodiment of transferring a measurement of a first object to a second object with a measurement and marking device according to the present invention;

Figures 7 is a flow diagram illustrating one embodiment of a method of printing a measurement marking on an object according to the present invention;

Figure 8 illustrates one embodiment of sensing a position of a housing relative to the object in the method of Figure 7;

Figure 9 illustrates another embodiment of sensing a position of a housing relative to the object in the method of Figure 7;

Figure 10 is a flow diagram illustrating one embodiment of a method of transferring a measurement of a first object to a second object according to the present invention; and

Figure 11 illustrates one embodiment of locating a feature of the first object and recording a position of a housing at the feature of the first object in the method of Figure 10.

Description of the Preferred Embodiments

In the following detailed description of the preferred embodiments, reference is made to the accompanying drawings which form a part hereof, and in which is shown by way of illustration specific embodiments in which the invention may be practiced. In this regard, directional terminology, such as "top," "bottom," "front," "back," "leading," "trailing," etc., is used with reference to the orientation of the Figure(s) being described. Since components of the present invention can be positioned in a number of different orientations, the directional terminology is used for purposes of illustration and is in no way limiting. It is to be understood that other embodiments may be utilized and structural or logical changes may be made without departing from the scope of the present invention. The following detailed description, therefore, is not to be taken in a limiting sense, and the scope of the present invention is defined by the appended claims.

Figures 1 and 2 illustrate one embodiment of a measurement and marking device 10 according to the present invention. Measurement and marking device 10 is a hand-held device configured for measuring an object 12, marking object 12 with a measurement, and/or transferring a measurement of object 12 to another object. Object 12 includes any material such as wood, plastic, steal, concrete, fabric, or other solid substance having at least one surface 14. As such, measurement and marking device 10 is positioned adjacent surface 14 of object

12 for measuring object 12, marking object 12, and/or transferring a measurement of object 12, as described below.

In one embodiment, measurement and marking device 10 includes a housing 20, a positional sensing assembly 30, a printhead assembly 40, a user interface 50, a controller 60, and a power supply 70. Positional sensing assembly 30, printhead assembly 40, user interface 50, controller 60, and power supply 70 are mounted in and/or on housing 20. Preferably, housing 20 is sized so as to be easily grasped and held in a hand of a user of measurement and marking device 10. Housing 20 has a side 22 oriented substantially parallel with surface 14 of object 12 when measurement and marking device 10 is positioned adjacent object 12. As such, side 22 of housing 20 follows surface 14 as measurement and marking device 10 is moved or advanced relative to object 12 by a user of measurement and marking device 10, as described below.

Positional sensing assembly 30 senses a position of measurement and marking device 10 and, more specifically, a position of housing 20 relative to object 12 as housing 20 is moved along surface 14 of object 12. As such, positional sensing assembly 30 measures a dimension of object 12 as housing 20 is moved relative to object 12. Positional sensing assembly 30 measures a dimension of object 12 by, for example, comparing a first position of housing 20 relative to object 12 with a second position of housing 20 relative to object 12. Example embodiments of positional sensing assembly 30 are described below with reference to Figures 3 and 4.

Printhead assembly 40 includes a printhead 42 and an ink supply 44 which supplies ink to printhead 42. As such, printhead 42 ejects drops of ink through a plurality of orifices or nozzles 46 (Figure 3) and toward object 12 so as to print on object 12. Nozzles 46 are arranged in one or more columns or arrays such that properly sequenced ejection of ink from nozzles 46 causes characters, symbols, and/or other graphics or images to be printed upon object 12 as housing 20 and, therefore, printhead assembly 40 is moved relative to object 12. Nozzles 46 are formed in a front face 48 (Figure 3) of printhead assembly 40 and front face 48 communicates with side 22 of housing 20 such that printhead assembly

40 prints on object 12 and, more specifically, surface 14 of object 12 as housing 20 is moved along surface 14 of object 12.

In one embodiment, user interface 50 includes a display 52 and one or more inputs 54. Display 52 includes a screen or other output surface which projects images to a user of measurement and marking device 10. Inputs 54 include, for example, buttons, keys, or switches which a user of measurement and marking device 10 may press for entry of information to measurement and marking device 10 or to operate and/or control functions of measurement and marking device 10. In addition, inputs 54 may permit a user of measurement and marking device 10 to interact with display 52 for input and/or selection of commands and/or functions of measurement and marking device 10. Display 52 and inputs 54 of user interface 50 are provided on a side of housing 20 for accessibility to a user of measurement and marking device 10.

Controller 60 includes a processor 62 and a memory device 64. Processor 62 includes logic circuitry which responds to and processes instructions for operating measurement and marking device 10. Memory device 64 receives and stores information for operation of measurement and marking device 10.

Controller 60 communicates with positional sensing assembly 30, printhead assembly 40, and user interface 50 to control operation of measurement and marking device 10. In one embodiment, controller 60 receives, for example, positional information from positional sensing assembly 30 and input information from user interface 50. As such, controller 60 processes the positional information and the input information and operates printhead assembly 40 to print on object 12, as described below. In addition, controller 60 conveys display information to display 52 of user interface 50.

Power supply 70 is mounted within housing 20 and supplies power for measurement and marking device 10. As such, power supply 70 communicates with controller 60 and user interface 50, printhead assembly 40, and/or positional sensing assembly 30. In one embodiment, power supply 70 communicates with user interface 50, printhead supply 40, and/or positional sensing assembly 30 via

controller 60. While power supply 70 is illustrated as communicating with user interface 50, printhead assembly 40, and/or positional sensing assembly 30 via controller 60, it is within the scope of the present invention for power supply 70 to communicate directly with and supply power directly to user interface 50, printhead assembly 40, and/or positional sensing assembly 30.

Power supply 70 includes, for example, a battery, including a rechargeable storage battery, which supplies electric current for measurement and marking device 10. In addition, power supply 70 may include an AC power adapter for accommodating the supply of alternating current to measurement and marking device 10.

Figure 3 illustrates one embodiment of positional sensing assembly 30. Positional sensing assembly 30 includes a wheel 32 which contacts surface 14 of object 12 as housing 20 is moved along surface 14 of object 12. As such, wheel 32 may include a frictional coating on a circumferential surface thereof to ensure rolling contact with surface 14 as housing 20 is moved along surface 14.

Wheel 32 is rotatably mounted in housing 20 and communicates with side 22 of housing 20 such that a portion of wheel 32 protrudes from side 22. As such, wheel 32 contacts object 12 and rotates relative to housing 20 as housing 20 is moved along surface 14 of object 12. In one embodiment, positional sensing assembly 30 includes, for example, a rotational encoder which senses rotation of wheel 32 and communicates the rotation with controller 60. Thus, rotation of wheel 32 correlates to an amount of movement of housing 20 relative to object 12 and, therefore, a position of housing 20 relative to object 12. As such, rotation of wheel 32 measures a dimension of object 12.

Figure 4 illustrates another embodiment of positional sensing assembly 30. Positional sensing assembly 30' includes an optical sensor 34 which senses surface 14 of object 12 as housing 20 is moved along surface 14 of object 12. Optical sensor 34 is mounted in housing 20 and communicated to side 22 of housing 20. As such, optical sensor 34 senses characteristics of surface 14 of object 12 as housing 20 is moved along surface 14 of object 12. Thus, changes in characteristics of surface 14 correlate to a change in position of housing 20

relative to object 12 and, therefore, an amount of movement of housing 20 relative to object 12. Accordingly, a position of housing 20 relative to object 12 and a dimension of object 12 can be established based on surface 14 of object 12.

While positional sensing assembly 30 is illustrated as including wheel 32 or optical sensor 34, it is within the scope of the present invention for positional sensing assembly 30 to include other positional and/or measurement sensing devices. For example, positional sensing assembly 30 may include a laser or an ultrasonic positional and/or measurement sensing device. In addition, positional sensing assembly 30 may include a combination of positional and measurement sensing devices. For example, positional sensing assembly 30 may include a laser for sensing a dimension of object 12 and wheel 32 for sensing a position of housing 20 relative to object 12 as housing 20 is moved along surface 14 of object 12.

In one embodiment, as illustrated in Figure 5, measurement and marking device 10 is used to print a measurement marking 80 on object 12. As such, side 22 of housing 20 is positioned adjacent surface 14 of object 12 and housing 20 is moved relative to object 12 by a user of measurement and marking device 10, as indicated by arrow 24. As housing 20 is moved relative to object 12, the position of housing 20 relative to object 12 is sensed by positional sensing assembly 30 as described above. Thus, when the position of housing 20 corresponds to a predetermined position, measurement marking 80 is automatically printed on surface 14 of object 12. Measurement marking 80 may include, for example, graphics and/or text such as symbols or annotations.

In one embodiment, the predetermined position includes a standard measurement or length unit such as an inch or centimeter and/or a plurality of scaled measurements or length units such as 1/8 scale, 1/2 scale, etc. Measurement marking 80, therefore, includes a plurality of spaced ticks 81 which are printed on surface 14 of object 12 by printhead assembly 40. As such, ticks 81 are spaced at predetermined intervals as input, specified, and/or selected by a user of measurement and marking device 10.

In addition, the predetermined position may include one or more distinct positions which are input, specified, and/or selected by a user of measurement and marking device 10. Thus, measurement marking 80 includes, for example, one or more distinct ticks 81 printed on surface 14 of object 12 by printhead assembly 40. As such, ticks 81 are spaced based on the position or positions input, specified, and/or selected by the user of measurement and marking device 10.

In another embodiment, as illustrated in Figures 6A-6E, measurement and marking device 10 is used to transfer a feature of a first object 12a and, more specifically, a measurement of first object 12a to a second object 12b. First object 12a and second object 12b, similar to object 12, each include at least one surface 14a and 14b, respectively. The feature of first object 12a includes, for example, a dimension of first object 12a, a position on first object 12a, and/or an association with first object 12a.

As illustrated in Figure 6A, measurement and marking device 10 is positioned adjacent surface 14a of first object 12a and moved or advanced relative to first object 12a, as indicated by arrow 24. As such, a position of housing 20 relative to object 12 is sensed by positional sensing assembly 30 and input to controller 60.

As illustrated in Figure 6B, a feature of first object 12a is located. For example, to transfer a dimension of first object 12a, housing 20 is moved across first object 12a to an edge of first object 12a. The edge of first object 12a, therefore, constitutes the feature of first object 12a. Thus, when measurement and marking device 10 is at the edge of first object 12a, the user of measurement and marking device 10 interacts with user interface 50 to input and, more specifically, locate the feature of first object 12a.

To locate the feature of first object 12a, a user of measurement and marking device 10 operates, for example, input 54 to record the position of the feature of first object 12a. As such, the position of housing 20 at the feature of first object 12a is automatically stored or recorded in measurement and marking device 10. Thus, the position of housing 20 at the feature of first object 12a

forms a predetermined position stored in controller 60. In addition, the position of housing 20 relative to first object 12a is recorded in controller 60 with any additional input to measurement and marking device 10 via, for example, user interface 50.

As illustrated in Figure 6C, measurement and marking device 10 is positioned adjacent surface 14b of second object 12b and moved relative to second object 12b, as indicated by arrow 24. As such, a position of housing 20 relative to second object 12b is sensed by positional sensing assembly 30 and input to controller 60, as described above.

As illustrated in Figure 6D, when the position of measurement and marking device 10 and, more specifically, the position of housing 20 relative to second object 12b coincides with the position of housing 20 at the feature of first object 12a, a mark 82 is printed on surface 14b of second object 12b. As such, mark 82 represents a transfer of the feature of first object 12a to second object 12b. More specifically, mark 82 represents a transfer of a dimension of and/or a dimension to the feature of first object 12a to second object 12b. While only one mark 82 is illustrated as being printed on second object 12b, it is within the scope of the present invention for one or more marks 82 to be printed on second object 12b.

Mark 82 includes, for example, graphics and/or text, such as symbols or annotations, or any combination of graphics and text. An example of mark 82 includes "CUT->|WASTE". As such, the example of mark 82 includes a symbol which indicates a cut line of second object 12b as transferred from and coinciding with the feature of first object 12a. In addition, the example of mark 82 includes an annotation which identifies which side of the cut line is considered "waste" or excess.

As illustrated in Figure 6E, measurement and marking device 10 may be moved or advanced beyond the position of second object 12b coinciding with the position of the feature of first object 12a to print additional graphics and/or text on surface 14b of second object 12b.

While measurement and marking device 10 is illustrated and described as locating and transferring one feature of first object 12a, it is understood that measurement and marking device 10 may locate and transfer any number of features of first object 12a. As such, the positions of such features are stored in memory device 64. In addition, user input, such as notes or references, may be input via user interface 50 and stored with the respective features.

While second object 12b is illustrated as being larger than first object 12a and Figures 6A-6E illustrate the transfer of a measurement from first object 12a to second object 12b, it is understood that a feature of second object 12b may be located and transferred from second object 12b to first object 12a. In addition, a feature of first object 12a may transferred to another portion of first object 12a. In addition, first object 12a may represent an object to be placed and second object 12b may represent and, therefore, be marked as an object to receive first object 12a. Furthermore, while measurement and marking device 10 is illustrated as locating and transferring a feature of first object 12a in one dimension, it is within the scope of the present invention for measurement and marking device 10 to locate and transfer features of first object 12a in one or more dimensions.

Figure 7 illustrates one embodiment of a method 100 of printing measurement marking 80 on object 12 according to the present invention. Reference is also made to Figures 1-6. At step 110, housing 20 is moved along surface 14 of object 12. More specifically, side 22 of housing 20 is positioned adjacent surface 14 of object 12 and housing 20 is moved relative to object 12, as illustrated, for example, in Figure 5. Preferably, side 22 of housing 20 is oriented substantially parallel with surface 14 of object 12 as housing 20 is moved relative to object 12.

At step 120, a position of housing 20 relative to object 12 is sensed. The position of housing 20 relative to object 12 is sensed by positional sensing assembly 30 and input to controller 60, as described above. Thus, controller 60 monitors the position of housing 20 relative to object 12.

At step 130, measurement marking 80 is printed on surface 14 of object 12 when the position of housing 20 relative to object 12 corresponds to a predetermined position. Measurement marking 80 is printed on surface 14 by printhead assembly 40 as controlled by controller 60. As such, controller 60 operates printhead assembly 40 to print measurement marking 80 on surface 14 of object 12 when the predetermined position is sensed by positional sensing assembly 30. Thus, measurement marking 80 corresponds with the predetermined position as recorded and/or stored in controller 60. The predetermined position and, therefore, measurement marking 80 includes, for example, a plurality of standard measurements or length units such as inches or centimeters or a plurality of scaled measurements or length units such as 1/8 scale, 1/2 scale, etc., as described above.

In one embodiment, at step 140, the predetermined position at which measurement marking 80 is printed is received and stored in controller 60. Preferably, prior to moving housing 20 along object 12 to sense the position of housing 20 and print measurement marking 80, the predetermined position for measurement marking 80 is received by controller 60 and stored in memory device 64. The predetermined position can include, for example, a position which is input, specified, or selected by a user of measurement and marking device 10 via, for example, user interface 50.

In addition, the predetermined position can include a position which is downloaded to measurement and marking device 10. For example, measurement and marking device 10 may communicate with a computer, computer server, or other computing device to receive a plurality of predetermined positions for a plurality of measurement markings 80. Thus, the plurality of measurement markings 80 may identify different measurements for the creation or fabrication of an item. The plurality of measurement markings may include, for example, measurements for a woodworking or metal fabrication project.

Figure 8 illustrates one embodiment of sensing the position of housing 20 relative to object 12 in step 120. As such, step 120 includes contacting surface 14 of object 12 with wheel 32 and rotating wheel 32 relative to housing 20, as

indicated in step 122. More specifically, wheel 32 is rotated relative to housing 20 as housing 20 is moved along surface 14 of object 12. As such, the position of housing 20 relative to object 12 is determined based on the rotation of wheel 32, as indicated in step 124. More specifically, the rotation of wheel 32 is correlated to an amount or distance of movement of housing 20 relative to object 12 and, therefore, a position of housing 20 relative to object 12 and a measurement of object 12, as described above.

Figure 9 illustrates another embodiment of sensing the position of housing 20 relative to object 12 in step 120. As such, step 120' includes sensing surface 14 of object 12 with optical sensor 34, as indicated in step 126. More specifically, optical sensor 34 senses characteristics of surface 14 as housing 20 is moved along surface 14 of object 12. As such, the position of housing 20 relative to object 12 is determined based on surface 14 of object 12, as indicated in step 128. More specifically, changes in characteristics of surface 14 correlate to a change in position of housing 20 relative to object 12 and, therefore, an amount or distance of movement of housing 20 relative to object 12 and a measurement of object 12, as described above.

Figure 10 illustrates one embodiment of a method 200 of transferring a measurement of first object 12a to second object 12b according to the present invention. Reference is also made to Figures 1-9. At step 210, housing 20 is moved along surface 14a of first object 12a. More specifically, housing 20 is positioned adjacent surface 14a of first object 12a and moved relative to first object 12a, as illustrated, for example, in Figures 6A and 6B.

At step 220, a position of housing 20 relative to first object 12a is sensed. The position of housing 20 relative to first object 12a is sensed by positional sensing assembly 30, as described above.

At step 230, a feature of first object 12a is located and a position of housing 20 at the feature is recorded. The feature of first object 12a is located by input to user interface 50 by a user of measurement and marking device 10, as described above. As such, the position of housing 20 relative to first object 12a is recorded in controller 60 with the input to user interface 50.

At step 240, housing 20 is moved along surface 14b of second object 12b. More specifically, housing 20 is positioned adjacent surface 14b of second object 12b and moved relative to second object 12b, as illustrated, for example, in Figures 6C and 6D.

At step 250, a position of housing 20 relative to second object 12b is sensed. The position of housing 20 relative to second object 12b is sensed by positional sensing assembly 30, as described above.

At step 260, mark 82 representing the feature or, more specifically, the measurement for the feature of first object 12a is printed on surface 14b of second object 12b. Mark 82 is printed on surface 14b of second object 12b when the position of housing 20 relative to second object 12b coincides with the position of housing 20 at the feature of first object 12a, as recorded in controller 60.

Mark 82 is printed on surface 14b of second object 12b in step 260 by printhead assembly 40 as controlled by controller 60. As such, controller 60 operates printhead assembly 40 to print mark 82 on surface 14b of second object 12b when the position coinciding with the recorded position of housing 20 at the feature of first object 12a is sensed by positional sensing assembly 30. Mark 82 includes, for example, graphics and/or text, as described above.

Figure 11 illustrates one embodiment of locating the feature of first object 12a and recording the position of housing 20 at the feature of first object 121 in step 230. As such, step 230 includes receiving input from a user of measurement and marking device 10 at the feature of first object 12a, as indicated in step 232. More specifically, the user of measurement and marking device 10 interacts with user interface 50 to indicate or input the feature of first object 12a when the position of housing 20 coincides with the feature of first object 12a. As such, the position of housing 20 is stored with the user input, as indicated in step 234. Thus, the user input and the associated position of housing 20 when the user input is received are stored in controller 60 and, more specifically, memory device 64.

By incorporating both measurement and marking capabilities within measurement and marking device 10, measurement and marking device 10 facilitates measurement of an object as well as marking of an object with measurement marking 80. More specifically, measurement and marking device 10 measures dimensions of an object, records and stores the dimensions, and subsequently prints the dimensions with annotations or other markings. As such, measurement and marking device 10 facilitates the transfer of a measurement from a first object to a second object. Thus, a user of measurement and marking device 10 need only handle or operate a single device for the transfer of a measurement from the first object to the second object. In addition, the need for a recording medium, such as paper, for recording of the measurement during the transfer is eliminated.

By providing measurement and marking device 10 with controller 60 and, more specifically, processor 62, measurement and marking device 10 can process and calculate predetermined positions for measurement markings 80 and/or mark 82. Such positions may be based on user input to controller 60 via user interface 50 or standard layouts stored in or downloaded to measurement and marking device 10. In addition, measurement and marking device 10 can automatically scale dimensions or measurements as well as compensate for common configurations such as equal or preset spacing.

Although specific embodiments have been illustrated and described herein for purposes of description of the preferred embodiment, it will be appreciated by those of ordinary skill in the art that a wide variety of alternate and/or equivalent implementations calculated to achieve the same purposes may be substituted for the specific embodiments shown and described without departing from the scope of the present invention. Those with skill in the chemical, mechanical, electro-mechanical, electrical, and computer arts will readily appreciate that the present invention may be implemented in a very wide variety of embodiments. This application is intended to cover any adaptations or variations of the preferred embodiments discussed herein. Therefore, it is

manifestly intended that this invention be limited only by the claims and the equivalents thereof.